Geologic Map of the Thousand Springs Quadrangle, Gooding and Twin Falls Counties, Idaho

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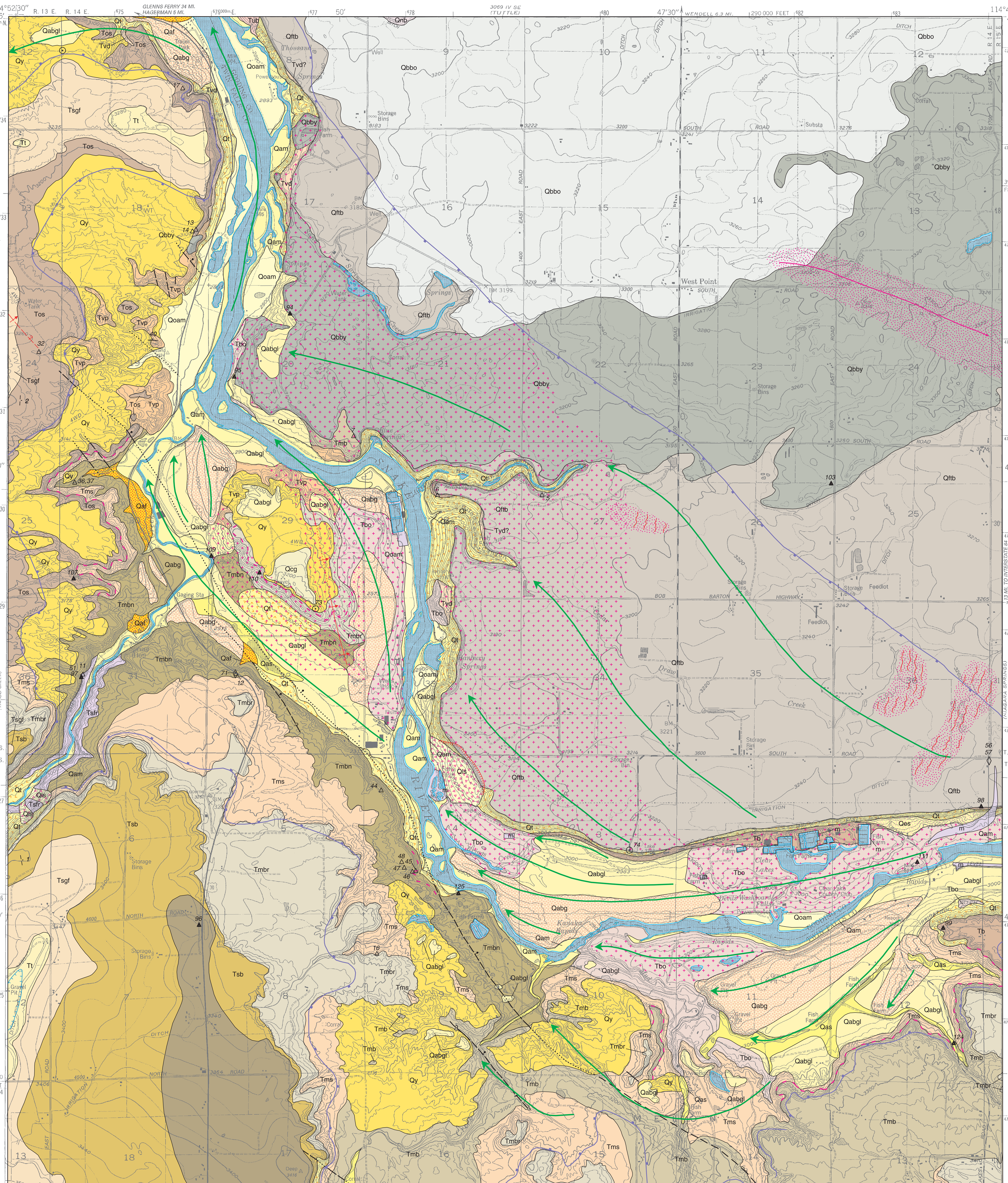
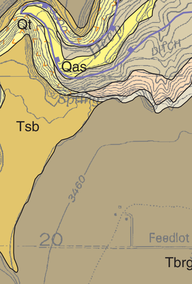


Base map scanned from USGS film positive, 1992.
Topography by photogrammetric methods from aerial photographs taken 1946. Updated from aerial photographs taken 1987-88 and field checked. Map edited 1992. Conflicts may exist between some updated features and previously mapped contours.
Polyconic projection. 1927 North American Datum.
10,000-food grid ticks based on Idaho coordinate system, central zone.
1000-meter Universal Transverse Mercator grid ticks, zone 11.
National geodetic vertical datum of 1929.

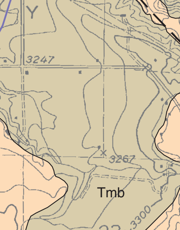


UTM Grid and 1971 Magnetic North Declination at Center of Map

SCALE 1:24,000

1 0.5 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 0.5 0 1 KILOMETER

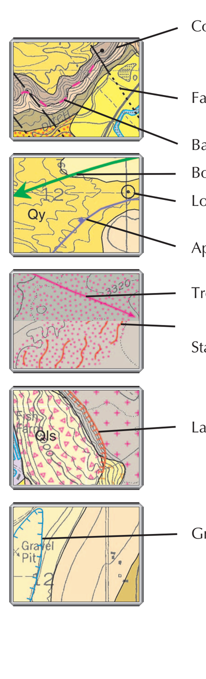
Contour interval 10 feet.
Supplemetary contour interval 10 feet.
Contour interval on river surfaces 5 feet.



QUADRANGLE LOCATION

Field work conducted 2003-2004.
This geologic map was funded in part by the USGS National Cooperative Geologic Mapping Program.
Digital cartography by Jane S. Freed at the Idaho Geological Survey's Digital Mapping Lab.
Map version 11-29-2005.
PDF map (Acrobat Reader) may be viewed online at www.idahogeology.org.

MAP SYMBOLS



Contact: Line showing the approximate boundary between one map unit and another. The location accuracy of an approximate contact is more than 80 feet on the ground.

Fault: Approximately located; dotted where concealed; queried where uncertain; ball and bar on downthrown side.

Baked sediments in contact with basalt flows.

Bonneville Flood flow direction.

Location of evidence for maximum stage of Bonneville Flood. Numbered location reported by O'Connor (1993).

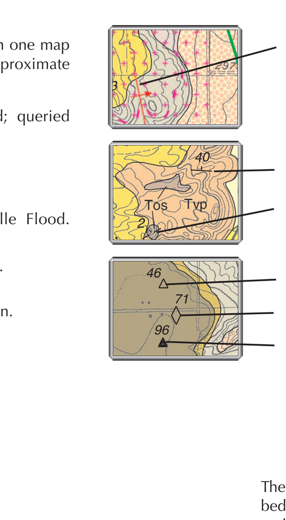
Approximate extent of Bonneville Flood at maximum stage.

Trend of dune field: arrow points in the downwind direction.

Stabilized dune field.

Landslide scarp and headwall: ticks show top of scarp.

Gravel pit that exposes a map unit.



Monoclinal fold: Dashed were approximately located; dotted where concealed; queried where uncertain.

Strike and dip of basalt flow or sedimentary bedding.

Estimated strke and dip of basalt flow.

Sample site for chemical and paleomagnetic analyses.*

Sample site for chemical analysis.*

Sample site for paleomagnetic analysis.*

*Data available at Idaho Geological Survey, igs@uidaho.

INTRODUCTION

The geologic map of the Thousand Springs quadrangle identifies both the bedrock and surficial geologic units. It shows the geographic distribution of rock types at the surface and in the shallow subsurface. The geologic units in the area control soil development, groundwater movement and recharge, and geotechnical factors important in construction design and waste management. Land uses in the area include irrigated agriculture, aquaculture, rural residential development, industrial and commercial enterprises, and dairy farms with confined animal feeding operations. In addition, a structurally controlled geothermal system exists in the western portion of the quadrangle and provides commercial hot water for recreational pools and greenhouses. Part of the Snake River Plain aquifer underlies the area and discharges as springs in the Snake River Canyon. Recent conflicts over water rights, water quantity and the conjunctive use of groundwater and the surface spring discharges have and will continue to affect economic development in the region.

Earlier geologic mapping by Malde and others (1963), Malde and Powers (1972), and Covington and Weaver (1991) was reviewed, and field checking of their maps was combined with new field investigations in 2003-2004 of both bedrock and surficial geology. Exposures of the geology were examined and selectively sampled. Aerial photographs were studied to aid in identifying boundaries between map units through photogeologic mapping of landforms. The information depicted at this scale furnishes a useful overview of the area's geology but is not a substitute for site-specific evaluations.

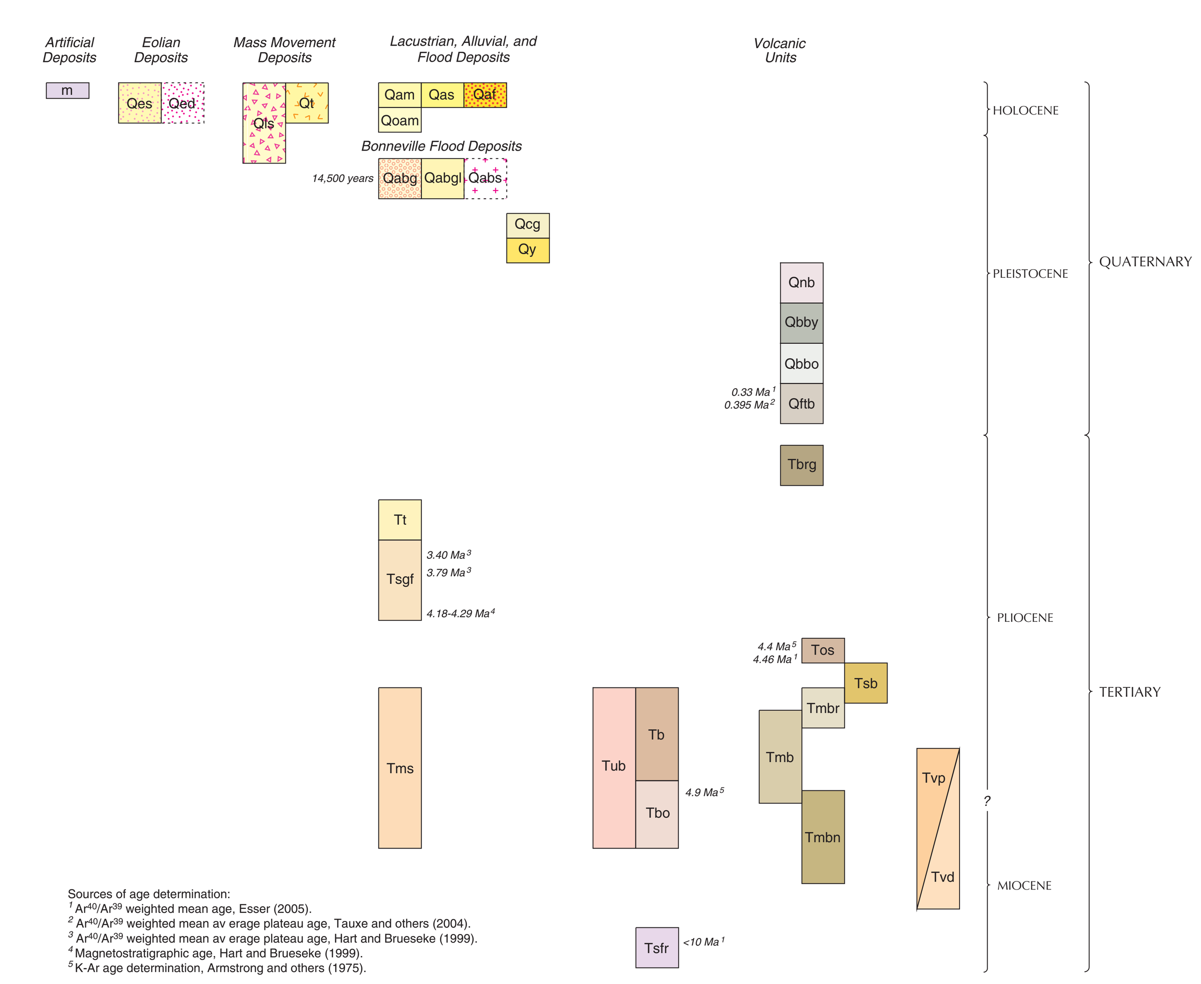
The Thousand Springs quadrangle lies near the center of the Snake River Plain, a large arcuate, lava-filled depression crossing southern Idaho. Pleistocene basalt flows from shield volcanoes to the north and east form the land surface east of the Snake River. Unconformably beneath the basalt and exposed on the uplands in the western part of the quadrangle are alluvial and lacustrine deposits of the Pliocene Glenns Ferry Formation. These overlie older basalt, volcaniclastic, and fine-grained sedimentary units, previously designated as the Banbury Basalt, which are exposed in the steep canyon walls and valley floor south and west of the river. A Tertiary rhyolite flow exposed in the bottom of Salmon Falls Creek canyon is the oldest rock unit mapped in the quadrangle. Approximately 14,500 years ago the Bonneville Flood filled the course of the Snake River canyon (O'Connor, 1993). The flood crossed over the canyon rim and flowed overland toward Sand Springs, eroding Box and Blind canyons and scouring basalt surfaces. In the valley the flood scoured the sedimentary deposits and basalt and locally deposited flood gravels.

DESCRIPTION OF MAP UNITS

ARTIFICIAL DEPOSITS

m — **Made ground (Holocene)**—Artificial fills composed of excavated, transported, and emplaced construction materials typically derived locally. Primarily areas modified for fish ponds.

CORRELATION OF MAP UNITS



Sources of age determination:
[1] Ar^{40}/Ar^{39} weighted mean age, Esser (2005).
[2] Ar^{40}/Ar^{39} weighted mean av erage plateau age, Tauxe and others (2004).
[3] Ar^{40}/Ar^{39} weighted mean av erage plateau age, Hart and Brueseke (1999).
[4] Magnetostratigraphic age, Hart and Brueseke (1999).
[5] K-Ar age determination, Armstrong and others (1975).

ALLUVIAL AND LACUSTRINE DEPOSITS

Qam — **Alluvium of mainstreams (Holocene)**—Channel and flood-plain deposits of the Snake River and Salmon Falls Creek. Stratified silt, sand, and gravel of channel bars, islands, and shorelines. Gravelly where channel is shallow and formed directly in basalt. In Salmon Falls Creek canyon includes terrace and alluvial-fan deposits. Typically 1-10 feet thick.

Qoam — **Older alluvium of mainstreams (Holocene)**—Channel and flood-plain deposits of the Snake River that form terraces 5-10 feet above river level. Primarily beds of sand, pebbles, and cobbles overlain by bedded to massive silt and sand. Grades and interfingers laterally into colluvium along valley sides.

Qas — **Alluvium of side-streams (Holocene)**—Channel and flood-plain deposits of tributaries to the Snake River. Stratified silt, sand, and gravel in Melon Valley.

Qaf — **Alluvial-fan deposits (Holocene)**—Stratified silt, sand, and gravel that form small fans adjacent to Salmon Falls Creek. Merges and is interstratified with alluvium (*Qam, Qas*). Thickness varies, but typically ranges 5-30 feet.

Bonneville Flood

Qabg — **Sand and gravel in giant flood bars (Pleistocene)**—Stratified deposits of boulders, cobbles, and pebbles of basalt in a matrix of coarse sand. Forms streamlined giant expansion bars with large-scale crossbeds. Deposited during highest-energy, maximum stage of flood. Similar to Melon Gravel (Malde and Powers, 1962; Malde and others, 1963; and Covington and Weaver, 1991), but restricted to Bonneville Flood constructional forms and deposits.

Qabgl — **Sand and gravel in eddy deposits and lower-energy bars (Pleistocene)**—Stratified coarse sand and pebble-cobble gravel deposited in eddys, side-channel positions, and lower-energy, waning-stage flood channels. Mantled with thin loess and minor fine-grained alluvium and slope wash.

Qabs — **Scabland of flood pathways (Pleistocene)**—Flood-scoured basalt surface. Where above the canyon rim, scoured surface is stripped of pre-flood soils but thin post-flood loess and sand are discontinuously present. In the canyon, sedimentary cover has been stripped and basalt surfaces have been plucked, gouged, and smoothed. Includes minor deposits of coarse sand that are not mapped at this scale. Some areas include pavements or strings of boulders transported by flood traction forces or that are lags from erosion by lower-energy regime during late stages of the flood.

Crowsnest Gravel (Pleistocene)—Stratified sand and pebble gravel that overlies Yahoo Clay (*Qy*). Gravel clasts composed of felsic volcanic rocks, quartzite, chert, and minor basalt. Map location suggests unit is channel deposits of ancestral Snake River that prograded across Yahoo Clay as McKinney Lake regressed (see *Qy*). Thickness about 6 feet. Original thickness and extent unknown owing to erosion by Bonneville Flood.

Qy — **Yahoo Clay (Pleistocene)**—Laminated to thin-bedded clay and silty clay. Pinkish white to light yellowish brown in color and conchoidal fracture when dry. Common parting along bedding and jointed vertically producing small blocks when exposed. Malde (1982) described the type locality near the mouth of Yahoo Creek, the lava-dam origin, and the distribution of the clay in the Snake River canyon from near Bliss to the Melon Valley. Stratigraphic evidence demonstrates the Yahoo Clay is younger than the basalt of Notch Butte (*Qnb*), but older than the Bonneville Flood. Malde (1982) attributes the clay to McKinney Lake, a temporary lake formed by damming of the Snake River by basalt of McKinney Butte. Malde's interpretation of the lake is compelling and his stratigraphic evidence was confirmed in our field mapping. Tauxe and others (2004) report an Ar^{40}/Ar^{39} weighted mean plateau age of 0.052 Ma for basalt of McKinney Butte (their sample sr16, McKinney Basalt). Malde and Powers (1972) and Covington and Weaver (1991) show the Yahoo Clay buried by Crowsnest Gravel except where dissected. However, our field mapping and the soil survey by Johnson (2002) suggest the Yahoo Clay is the significant mappable unit at the land surface. The erosion surface attributed to the Crowsnest Gravel by Malde and Powers (1972) appears graded to the level of McKinney Lake. Locally the Yahoo Clay is capped by unmapped thin sheet-wash deposits with common lag gravels derived from erosion of the Tuana Gravel (*Tt*) and the basalt of Oster Lakes (*Tos*).

Tt — **Tuana Gravel (Pliocene)**—Well bedded and sorted pebble and cobble gravel interbedded with layers of sand and silt. Gravel-clast lithologies suggest the gravel was deposited by an ancestral Salmon Falls Creek that prograded braided streams deposits across a high, nearly flat plain formed on the Glenns Ferry Formation. Near the Snake River, thin eroded remnants are exposed in gravel pits where the gravel overlies Glenns Ferry Formation at an elevation of 3,200-3,240 feet. Named by Malde and Powers (1962). Sadler and Link (1996) report on provenance, paleocurrents, and geochronology of the Tuana Gravel, which largely corroborate the descriptions of Malde and Powers (1962). The age of Tuana Gravel remains poorly constrained, but Malde (1991) and Othberg (1994) suggest the Tuana Gravel and the Tenmile Gravel near Boise, apparently graded to the same base level, are correlative. A minimum age for Tuana Gravel mapped to the northwest is 1.92 ± 0.16 Ma (Malde, 1991). A minimum age for the Tenmile Gravel is 1.58 ± 0.085 (Othberg, 1994). These gravels represent fluvial and glacial regimes driven by initiation of cooler climate in the late Pliocene, but before early Pleistocene incision of the western Snake River Plain (Othberg, 1994).

Tsgf — **Glenns Ferry Formation (Pliocene)**—Poorly consolidated, bedded lake and stream deposits. Primarily flood plain lithofacies in the Thousand Springs quadrangle that include calcareous olive silt, dark clay, sand locally cemented, and fine-pebble gravel (Malde and Powers, 1962; Malde and Powers, 1972; Malde, 1972; McDonald and others, 1996). To the west and northwest of the Thousand Springs quadrangle the formation includes intercalated but laterally inextensive basalt flows and beds of tephra. Repenning and others (1995) interpret the ages of various localities included in the Glenns Ferry Formation, and present a paleogeographic history of Pliocene to early Pleistocene lake and stream deposits in the western Snake River Plain. The basin-filling contribution of the Glenns Ferry Formation to the western Snake River Plain's tectonic subsidence is described by Wood and Clemens (2002). Northwest of the Thousand Springs quadrangle, mammalian fossils in deposits at the Hagerman Fossil Beds National Monument are middle Blancan (Pliocene) in age (Repenning and others, 1995). Hart and Brueseke (1999) corroborate the Pliocene age with Ar-Ar dates on basalt ranging from 3.4 to 3.8 Ma.

Tms — **Sediment of Melon Valley (Pliocene-Miocene?)**—Light tan to white, pale greenish, or pinkish, fine- to medium-grained, bedded lake and stream deposits with tephra beds and rare, glassy plagioclase-olivine phyric, valley-filling basalt flows. Typically very fine-grained, nondescript sediments, but greenish-gray and local conglomeratic beds with rounded cobbles of Paleozoic rocks were noted at several localities. At one locality, a buried soil horizon was exposed suggesting an intermittent erosional unconformity within the unit. Malde and Powers (1972) mapped the unit as Tbs (Sedimentary deposits of the middle part of the Banbury Basalt) and noted brownish channel sands and pebble gravels as well as the lake deposits with local diatomite and silicic ash beds. They ascribe a thickness of as much as 100 feet to the unit, which seems reasonable for the exposed part of the section. However, driller's logs from water wells drilled in the Melon Valley area suggest there may be several hundred feet of interbedded lava flows and sediments below the current exposure level.

EOLIAN DEPOSITS

Qed — **Dune sand (Holocene)**—Stratified fine sand of stabilized wind dunes. Shown only where identified on aerial photographs. Formerly more extensive based on descriptions of Youngs and others (1929). Fine-sand soils with little or no pedogenic horizonation were associated with dune morphology when present in the early 20th century (Youngs and others, 1929). Remnants identified and mapped using 1972 aerial photographs (NASA color infrared photography). Continued agricultural modifications to the land have tended to smooth topography and homogenize soils. The result has been an obliteration of the original topography, which probably included extensive areas of stabilized dunes.

Qes — **Eolian sand of the Snake River Canyon (Holocene)**—Uncompacted fine sand deposited by wind along the base of canyon walls.

MASS MOVEMENT DEPOSITS

Qt — **Talus (Holocene)**—Angular pebble-, cobble-, and boulder-sized fragments of basalt that have broken off nearly vertical rock walls and accumulated below. Deposits are characterized by a steeply sloping surface that is at or near the angle of repose. Talus postdates the Bonneville Flood, and the thick, mappable talus has nearly to completely buried a "stepped" canyon wall formed by differential erosion of younger versus older basalt exposed in the canyon. Not mapped where thin talus partially covers older basalt. Unit may include small deposits of eolian or water-reworked fine sand that typically occur at the toes of the talus slope, and which are similar to *Qes*.

Qls — **Landslide deposits (Holocene and Pleistocene)**—Unsorted and nonstratified basalt cobbles and boulders mixed with silt and clay. In addition to the landslide deposit, the unit includes the landslide scarp and the headwall (steep area adjacent to and below the landslide scarp) from which material broke away (see Symbols). The headwall area may include talus formed after landslide movement.

BASALT UNITS

The surficial geology of the Snake River Plain north of the Snake River is primarily Pleistocene basalt flows of the Snake River Group. North of the Snake River the younger basalt units originated from several shield volcanoes north and east of the quadrangle, whereas older Pliocene and Miocene basalt units originated south of the Snake River. Each volcano probably extruded numerous lava flows or flow lobes, although individual flows cannot easily be mapped, especially on the older surfaces now subdued by surficial deposits. Older basalt surfaces tend to be less rugged and more subdued than younger surfaces, primarily the result of greater accumulation of loess over a longer period of time.

Qnb — **Basalt of Notch Butte (Pleistocene)**—Fine-grained, dark gray to black basalt with common to abundant olivine phenocrysts and clots 0.5 to 1.5 mm in diameter. Locally contains a few small plagioclase phenocrysts as much as 1 mm in length, or scarce to rare glomerocrysts of plagioclase and olivine as much as 5 mm. Remanent magnetic polarity is normal, as determined in the field and through laboratory analysis. Source is Notch Butte located 21 miles northeast of the quadrangle. A small lobe extends onto the quadrangle from the north. Equivalent to the Wendell Grade Basalt of Malde and Powers (1962) and Malde and others (1963).

Qbby — **Basalt of Bacon Butte, younger unit (Pleistocene)**—Fine- to medium-grained, dark gray basalt with common to abundant olivine as grains and clots as much as 3 mm and scattered small plagioclase laths. Similar in texture and appearance to basalt of Notch Butte, although slightly coarser grained overall. Remanent magnetic polarity is normal, as determined in the field and through laboratory analysis. Forms a raised, hilly surface of partly exposed pressure ridges that trends from east-to-west into the Sand Springs area in the Snake River canyon, where Malde and others (1963) mapped it as Sand Springs Basalt. The surface was scoured where the Bonneville Flood crossed the upland, rendering an appearance that could be mistaken for a younger basalt, such as basalt of Rocky Butte. However, we believe this unit is a late flow or series of flows erupted from Bacon Butte located 18 miles northeast of the quadrangle, which was named for "Bacon Ranch." The name "Bacon Butte" is derived from nearby Bacon Ranch, located on the east side of the butte. The name was also used by Covington and Weaver (1991). Surface drainage is not developed to poorly developed. Discontinuous loess and eolian sand deposits cover less than 50 percent of the surface and are 1-10 feet thick. Soil caliche (duripan) is commonly well developed within the soil profile (Youngs and others, 1929; Johnson, 2002) and at the soil-basalt contact, but the thickness of caliche varies considerably. Some of the land is cultivatable and some is used as pasture.

Qbbo — **Basalt of Bacon Butte, older unit (Pleistocene)**—Fine-grained, dark gray basalt with common to abundant plagioclase laths as much as 5 mm in length and common olivine grains and clots, commonly as intergrowths with plagioclase. Locally diktytaxitic. May exhibit abundant carbonate accumulation in vesicles and fractures. Remanent magnetic polarity is normal, as determined in the field and through laboratory analysis. Also erupted from Bacon Butte located 18 miles northeast of the quadrangle. Included in Thousand Springs Basalt by Malde and others (1963). Topography contrasts with areas of basalt of Notch Butte and the basalt of Bacon Butte, younger unit. Few basalt pressure ridges rise above a nearly complete mantle of loess and dune sand. Surface drainage is moderately developed. Thickness of mantle ranges 3-25 feet; commonly 3-12 feet thick. Soil caliche (duripan) is typically well developed within the soil profile (Johnson, 2002) and at the soil-basalt contact, but the thickness of caliche is highly variable. Most of the land is cultivatable.

Qftb — **Basalt of Flat Top Butte (Pleistocene)**—Fine-grained, medium gray basalt with scattered to very abundant plagioclase-olivine intergrowths 4-7 mm, and olivine grains and clots 1-4 mm. Flows typically vesicular near the top and more dense in the center, but diktytaxitic throughout with abundant fine-grained plagioclase laths. Consists of several flows or flow units. Carbonate coatings and fillings common in voids but not pervasive. Remanent magnetic polarity is normal, as determined in the field and through laboratory analysis. Erupted from the Flat Top Butte located 17 miles east of the quadrangle. Equivalent to Thousand Springs Basalt of Malde and Powers (1972) and Malde and others (1963). Includes some areas mapped as Sand Springs Basalt by Malde and others (1963) and Covington and Weaver (1991). Tauxe and others (2004) report an $^{40}Ar/^{39}Ar$ weighted mean plateau age of 0.395 Ma for this unit (their sample sr09, Thousand Springs Basalt). An $^{40}Ar/^{39}Ar$ weighted mean age of 0.33±0.08 Ma was obtained on our sample 02P002B (Esser, 2005). Basalt flows of unit inundated through-flowing drainage and appear to define location of ancestral Snake River near Thousand Springs. Southern edge of unit formed location of ancestral Snake River along which the present canyon was cut. Forms relatively smooth topography with gentle westerly slope which is partially stripped where the Bonneville Flood crossed the upland. Topography contrasts with area of *Qbby* to the north. Few basalt pressure ridges rise above a nearly complete mantle of loess and dune sand. Surface drainage is moderately developed. Thickness of mantle ranges 3-25 feet; commonly 3-12 feet thick. Soil caliche (duripan) is typically well developed within the soil profile (Johnson, 2002) and at the soil-basalt contact, but the thickness of caliche is highly variable. Most of the land is cultivatable.

Tbrg — **Basalt of Burger Butte (late Pliocene)**—Fine- to medium-grained basalt generally with abundant plagioclase phenocrysts as large as 5 mm and olivine phenocrysts about 1 mm in diameter. Remanent magnetic polarity is reverse as determined in the field and through laboratory analysis. Source is Burger Butte and associated satellite vents located 16 miles southeast of the quadrangle. Most of the unit is equivalent to the "basalt of Sucker Flat" unit of Bonnichsen and Godchaux (1997b) in the adjacent Buhl quadrangle. No basalt pressure ridges rise above loess mantle. Surface drainage is moderately well developed. Loess thickness ranges 5-25 feet and typically comprises a younger deposit with weak soil development and an underlying older loess with a thick caliche (duripan) horizon (Baldwin, 1925; Ames, 2003).

Tos — **Basalt of Oster Lakes (Pliocene)**—Grainy, fine- to medium-grained but coarse-textured vesicular basalt. Dark gray to brownish gray or brick colored with a light purplish hue in places. Abundant plagioclase phenocrysts as much as 5 mm in length; groundmass is glassy in places. Unit is subaerial and quite fresh where exposed near the fish hatcheries at Oster Lakes. Includes some sedimentary interbeds in the Thousand Springs quadrangle. Remanent magnetic polarity is normal, as determined in the field and through laboratory analysis. Field relations suggest it stratigraphically and probably unconformably overlies the *Tvd* vent tephras and the altered or water-affected basalt flows (*Tub*) and *Tmbr*, which have reverse polarity where analyzed. Source or sources undetermined, but may be to the west or southwest. Previously mapped as "Banbury Basalt, basalt of upper part" by Malde and Powers (1972) and Covington and Weaver (1991). A K-Ar age determination by Armstrong and others (1975) on this unit is 4.4±0.6 Ma. An $^{40}Ar/^{39}Ar$ weighted mean age of 4.46±0.39 Ma was obtained on our sample 03VG039 (Esser, 2005).

Tsb — **Basalt of Sunset Butte (Pliocene)**—Fine-grained, medium to dark gray basalt with common to abundant plagioclase phenocrysts 4 to 8 mm in length. Remanent magnetic polarity is reverse as determined in the field and through laboratory analysis. Source is Sunset Butte located 6 miles southwest of Melon Valley. Vesicular pahoehoe basalt exposed on the rim of Salmon Falls Creek canyon northwest of the butte abruptly changes to massive columnar basalt. Malde and Powers (1972) and Bonnichsen and Godchaux (1997a, 1997b) identify the source for the Lucerne basalt (or Lucerne School basalt) as Sunset Butte. However, we believe the source for the Lucerne basalt may have been Burger Butte. *Tmbr* flows beneath the basalt of Sunset Butte in Salmon Falls Creek canyon and the western part of Melon Valley may also have originated from Sunset Butte.

Tmb — **Basalt of Melon Valley, undivided (early Pliocene or late Miocene?)**—Brownish-weathering, weakly altered aphyric to phyric, olivine-plagioclase and olivine basalt. Forms subdued, columnar lava flows as thick as 50 feet and thinner vesicular flows 15 feet thick. Flow slightly bakes and buries paleosol in sediments (exposed on Highway 30 roadcut in north edge Section 5, T9S, R14E). Alteration includes trace chlorite and clay and may be due to combinations of saprolitic spheroidal weathering, internal alteration from water picked up during emplacement (Godchaux and Bonnichsen, 2002), and very weak hydrothermal alteration in a geothermal system. Includes normal and reverse polarity flows. Within Melon Valley, may be equivalent in part to either *Tmbr* or *Tmbn*, or may be unrelated sequence of basalt flows. Equivalent in part to undivided basalt flows (*Tb*) east of Melon Valley.

Tmbr — **Basalt of Melon Valley, reverse polarity flows (early Pliocene)**—Brownish-weathering, fresh to altered aphyric to phyric, olivine-plagioclase and olivine basalt. Remanent magnetic polarity is reverse based on field and laboratory analysis. In the field, a few flows have weak normal or conflicting polarity. Columnar flows are as thick as 50 feet and thinner vesicular flows are about 15 feet thick. Normally overlies *Tms* unit but may locally lie directly on *Tmb* or *Tmbn* flows. At least four flows are present beneath a basalt of Sunset Butte flow in Salmon Falls Creek canyon and may be a series of early flows erupted from Sunset Butte. Other flows may be from shield volcanoes south of the map area. Includes some water-affected basalt (Sucker Flat basalt, altered facies) of Bonnichsen and Godchaux (1997b) in the Melon Valley area. Malde and Powers (1972) mapped much of this basalt as *Tbu*, "Banbury Basalt, basalt of upper part".

Tmbn — **Basalt of Melon Valley, normal polarity flows (late Miocene?)**—Brownish-weathering, weakly altered aphyric to very phyric, olivine-plagioclase and olivine basalt. Remanent magnetic polarity is normal based on field and laboratory analysis. Forms subdued, columnar lava flows as thick as 50 feet and thinner vesicular flows 15 feet thick. Flow slightly bakes and buries paleosol in sediments (exposed on Highway 30 roadcut in north edge Section 5, T9S, R14E), Alteration includes trace chlorite and clay and may be due to combinations of saprolitic spheroidal weathering, internal alteration from water picked up during emplacement (Godchaux and Bonnichsen, 2002), and very weak hydrothermal alteration in a geothermal system. Minor sedimentary interbeds include light-colored clay, silt, sand, and pebble gravel. Reed casts in lacustrine clay beds immediately under the basalt were noted in two localities. An $^{40}Ar/^{39}Ar$ age determination on a sample collected during this mapping project resulted in an age of 6.90±0.46 Ma. Chemical similarities to basalts in upper Salmon Falls Creek canyon south of the Twin Falls 30' x 60' quadrangle indicate the source(s) for the *Tmbn* flows may be from that area. Malde and Powers (1972) mapped these as *Tbl*, "Banbury Basalt, basalt of lower part".

Vent facies of basaltic tephra (early Pliocene or late Miocene?)—Crudely layered pyroclastic and volcaniclastic deposits exposed in the Snake River canyon. Includes coarse-grained proximal vent facies (*Tvp*) and stratigraphically equivalent fine-grained distal facies (*Tvd*). Proximal facies are called tuff of Blue Heart Springs by Bonnichsen and Godchaux (2002).

Tvp — **Vent deposits, proximal facies (early Pliocene or late Miocene?)**—Coarse tuff breccias (blocks to 1-meter diameter), thick air fall tuffs, probable base surge deposits, cinders, and spatter-laden deposits in local phreatomagmatic vent complexes that include the prominent Riverside cone of Stearns and others (1939) and the "Thousand" vent, located in section 29 and sections18 and 19 respectively, T. 8 S., R. 14 E. Includes sequences of explosively erupted layers of ash- to block-sized juvenile tephra and accidental fragments, locally tilted in the vent complex. Proximal facies were mapped by Malde and Powers (1972) who assigned them to the lower Banbury Basalt. Proximal facies are called "tuff of Blue Heart Springs" by Bonnichsen and Godchaux (2002), named for a spring near the Riverside cone. Small stream pebbles and blocks of coherent bedded clay, as well as spatter and blocks of older coarse-grained basalt, are present in the vent deposits. Small exposure of basalt flow over the Riverside cone is included in *Tvp* but may be equivalent to *Tmbr* unit. Age poorly constrained. Both vents appear to be unconformably overlain by *Tos*, *Tmbr*, or *Tb*, but the exact nature of the contact with *Tbo* (lower Banbury Basalt unit of Malde and Powers, 1972) is problematic.

Tvd — **Vent deposits, distal facies (early Pliocene or late Miocene?)**—Crudely layered, variably colored, tan to orangish brown, pyroclastic and volcaniclastic deposits poorly exposed along the south Snake River canyon wall near the southeastern corner of the quadrangle. Correlative to parts of the Banbury volcanics of Stearns and others (1938) and the *Tbls* and *Tbu* units mapped by Malde and Powers (1972). Distal facies tuffaceous and volcaniclastic deposits appear to grade laterally into more proximal facies (*Tvp*) where several vents occur along the Snake River. Unit includes cyclically repeated air fall tuff, local spatter, pebbly gravel deposits suggestive of reworking, and locally palagonitized tuff. Overlain unconformably locally by sediments, the upper surface of which is baked by *Tos*.

Tb — **Basalt flows, undivided (early Pliocene to late Miocene?)**—Fine- to coarse-grained, unaltered to altered undivided basalt flows exposed in the Snake River canyon. Stratigraphically above *Tbo* unit and commonly separated from it by a thin orange baked soil or sediment horizon 1-2 feet thick. Source(s) unknown, but probably consists of flows from different sources of different ages. Includes some basalt mapped as "Sucker Flat basalt, altered" by Bonnichsen and Godchaux (1997b) in the adjacent Buhl quadrangle. Near Melon Valley, may be equivalent in part to *Tmbr* or to *Tmb*.

Tbo — **Older basalt flows, undivided upstream from Thousand Springs (early Pliocene to late Miocene)**—Medium- to coarse-grained, gray to sooty brown, mostly altered or weathered basalt flows exposed in the lower part Snake River canyon. Source(s) unknown but probably erupted from the south and southeast. Age poorly constrained but probably includes flows from different sources of different ages. One K/Ar age determination on this unit by Armstrong and others (1975), from an outcrop at the base of Clear Lakes grade, resulted in an age of 4.9±0.6 Ma, indicating it is younger than our *Tmbn* unit at that location. May be equivalent in part to *Tub* or *Tmbr*. All flows included in this unit that were analyzed for remanent magnetism have reverse polarity, although all may not be age-equivalent and not all flows were analyzed. Malde and Powers (1972) included most of these flows in their "Banbury Basalt, basalt of lower part". Extensively scoured by the Bonneville Flood.

Tub — **Older basalt flows, undivided, downstream from Thousand Springs (early Pliocene to late Miocene)**—Medium- to coarse-grained, gray to sooty brown, dense to altered or weathered basalt flows exposed in the lower part of the Snake River canyon from just north of Thousand Springs. Source(s) unknown but may be from the south and southwest. Age is poorly constrained, but underlies sediment of the Glenns Ferry Formation (*Tsgf*). May be equivalent in part to *Tbo* or *Tmbr*. All flows in this unit that were analyzed for remanent magnetism have reverse polarity, although all may not be age-equivalent and not all flows were analyzed. Malde and Powers (1972) included most of these flows in their "Banbury Basalt, basalt of upper part". Stearns and others (1938) included them in the Banbury volcanics.

RHYOLITIC UNITS

Tsfr — **Rhyolite of Salmon Falls Creek (Miocene)**—Purple-gray weathering, devitrified rhyolite and dacite lava flows and vitrophyre that crop out in the lower parts of the canyon of Salmon Falls Creek. Remanent magnetic polarity is normal, as determined in the field and through laboratory analysis. Probably genetically and stratigraphically associated with a rhyolitic lava flow and a welded ash-flow tuff mapped upstream (Bonnichsen and Godchaux, 1997a). Lithologically similar to the Shoshone Falls rhyolite exposed near Twin Falls. Flow folding and banding common. Phenocrysts are plagioclase, pyroxene, and opaque minerals. Groundmass is glassy to partially devitrified with microlites. An $^{40}Ar/^{39}Ar$ age determination on our sample 03SFR-v collected near the mouth of Salmon Falls Creek canyon resulted in a low-confidence age of <10 Ma.

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